

FIG. 1

	Nd	Pr	Dy	Co	Cu	Al	B	Zr	Fe	[wt%]
LOW R ALLOY	23.0	6.1	0.6	—	0.05	0.20	1.1	0.16	bal.	
HIGH R ALLOY	40.3	—	—	5.1	0.05	0.20	—	—	bal.	
COMPOSITION OF SINTERED BODY	24.5	5.5	0.5	0.5	0.05	0.20	1.0	0.15	bal.	

FIG. 2

SAMPLE NO.	d [μm]	ρ [Mg/m <sup>3</sup> ]	Br [T]	HcJ [kA/m]	(BH) <sub>max</sub> [kJ/m <sup>3</sup> ]	H <sub>k</sub> /H <sub>cJ</sub> [%]	O <sub>2</sub> [ppm]	N <sub>2</sub> [ppm]	C [ppm]
1	3.2	7.524	1.441	1120.2	399.6	97.82	760	490	750
2	3.5	7.526	1.443	1013.5	400.6	97.36	700	410	710
3	3.7	7.525	1.442	1099.7	400.3	97.88	440	380	810
4	4.1	7.523	1.442	1070.8	400.1	97.67	570	390	710
5	4.4	7.528	1.439	1059.6	398.5	97.95	750	270	810

FIG. 3

MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)			
	SAMPLE NO. 1 ( $d=3.2 \mu m$ )	SAMPLE NO. 2 ( $d=3.5 \mu m$ )	SAMPLE NO. 3 ( $d=3.7 \mu m$ )	SAMPLE NO. 4 ( $d=4.1 \mu m$ )
0	0	0	0	0
80	8.2	10.0	10.2	9.6
160	18.1	28.9	27.9	28.9
240	36.7	49.3	49.1	49.5
320	49.7	66.7	67.1	68.5
400	60.9	75.6	75.7	77.5
480	69.5	81.1	81.0	82.4
560	74.1	84.6	84.8	85.4
640	79.3	88.0	88.9	89.3
800	86.9	93.5	93.2	93.6
960	93.2	96.4	96.8	97.3
1200	97.7	98.1	99.1	99.1
1600	99.5	99.1	99.5	100
2000	100	100	100	100

d = MEAN GRAIN SIZE

FIG. 4

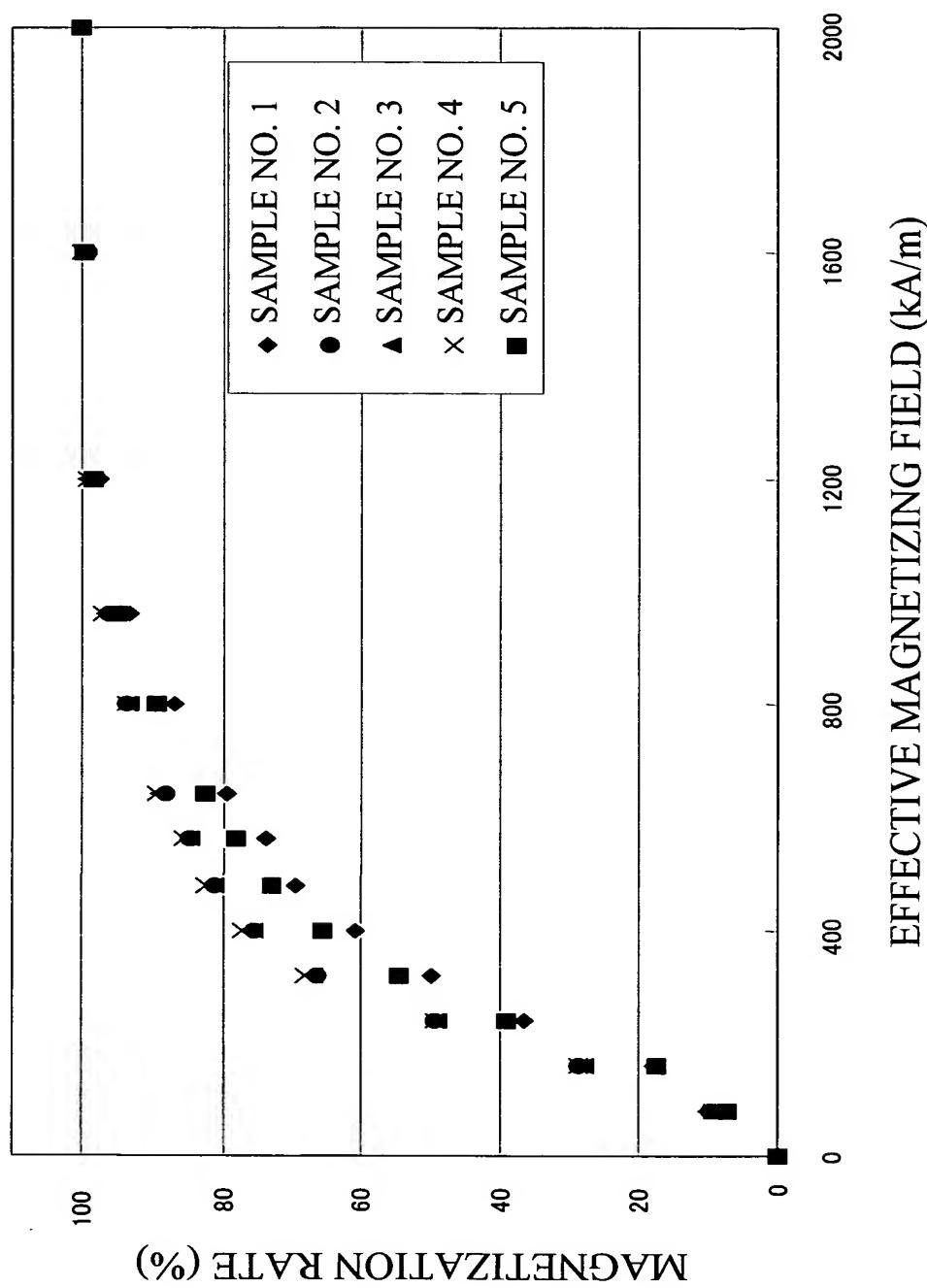


FIG. 5

MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)			
	SAMPLE NO. 1 ( $d=3.2 \mu m$ )	SAMPLE NO. 2 ( $d=3.5 \mu m$ )	SAMPLE NO. 3 ( $d=3.7 \mu m$ )	SAMPLE NO. 4 ( $d=4.1 \mu m$ )
40	320	240	240	240
50	400	320	320	320
60	400	320	320	320
70	560	400	400	400
80	800	480	480	480
90	960	800	800	800
95	1200	960	960	960
				1200

$d$  = MEAN GRAIN SIZE

FIG. 6

	Nd	Pr	Dy	Co	Cu	Al	B	Zr	Fe	[wt%]
LOW R ALLOY	23.0	6.1	0.6	-	0.05	0.20	1.1	0.06	bal.	
HIGH R ALLOY	40.3	-	-	5.1	0.05	0.20	-	-	bal.	
COMPOSITION OF SINTERED BODY	24.5	5.5	0.5	0.5	0.05	0.20	1.0	0.05	bal.	

FIG. 7

SAMPLE NO.	T <sub>s</sub> (°C)	d [μm]	ρ [Mg/m <sup>3</sup> ]	B <sub>r</sub> [T]	H <sub>cJ</sub> [kA/m]	(BH) <sub>max</sub> [kJ/m <sup>3</sup> ]	H <sub>k</sub> /H <sub>cJ</sub> [%]	O <sub>2</sub> [ppm]	N <sub>2</sub> [ppm]	C [ppm]
6	1010	4.4	7.53	1.445	1076.2	403.2	96.68	580	350	710
7	1050	4.1	7.54	1.442	1082.6	400.5	98.02	2130	270	770
8	1070	4.3	7.55	1.438	1055.8	398.3	97.65	3430	270	750

FIG. 8

MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)		
	SAMPLE NO. 6	SAMPLE NO. 7	SAMPLE NO. 8
0	0	0	0
80	8.0	7.8	6.6
160	23.8	14.7	13.0
240	41.4	28.9	24.1
320	61.6	47.2	40.9
400	73.7	62.5	55.7
800	95.4	93.8	91.9
1600	100	100	100
2000	100	100	100

FIG. 9

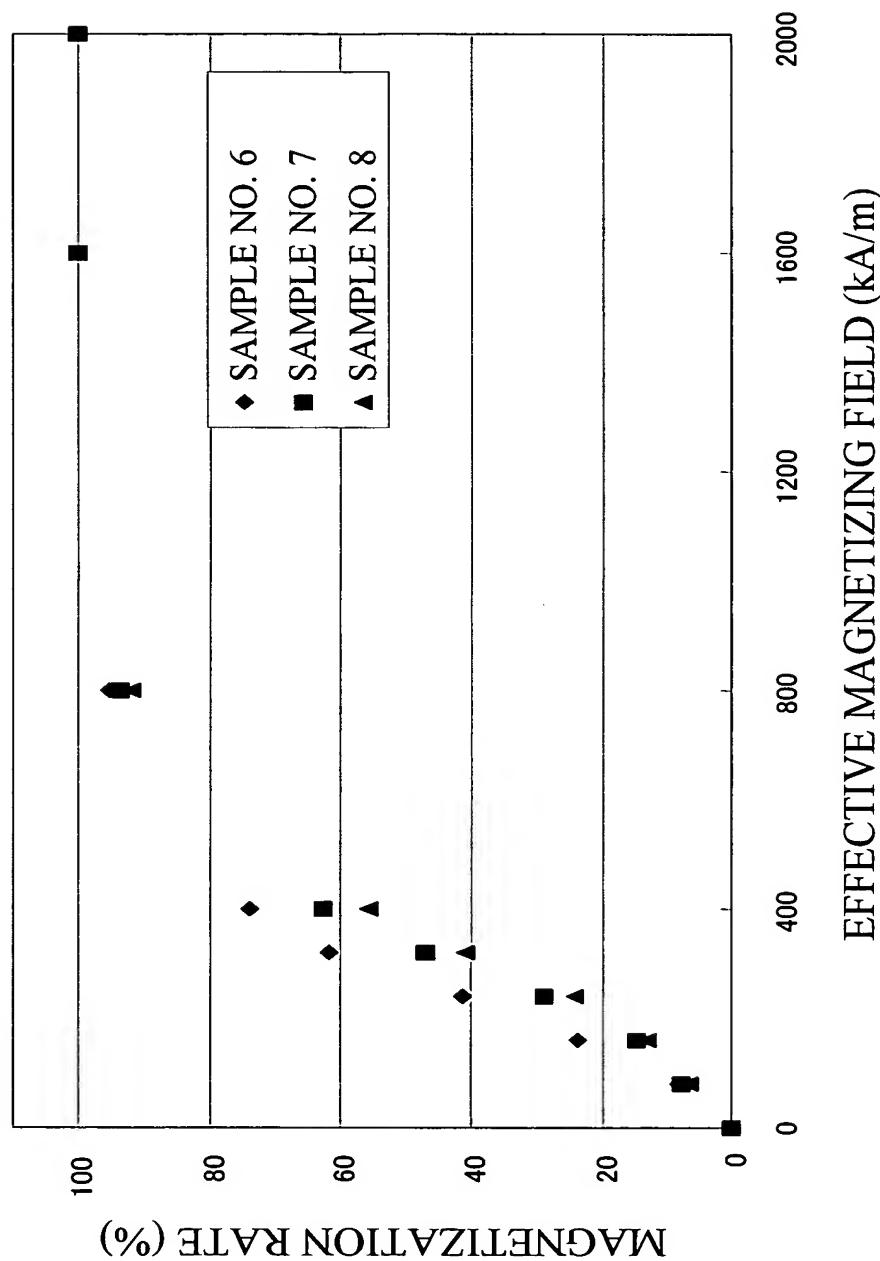


FIG. 10

SAMPLE NO.		Nd	Pr	Dy	Co	Cu	Al	B	M(Zr,Ti)	F <sub>e</sub>	[wt%]
9	LOW R ALLOY	23.0	6.1	0.55	—	0.05	0.20	1.1	—	bal.	
	HIGH R ALLOY	40.3	—	—	5.1	0.05	0.20	—	—	bal.	
10	COMPOSITION OF SINTERED BODY	24.5	5.5	0.5	0.5	0.05	0.20	1.0	—	bal.	
	LOW R ALLOY	23.0	6.1	0.55	—	0.05	0.20	1.1	0.22(Zr)	bal.	
11	HIGH R ALLOY	40.3	—	—	5.1	0.05	0.20	—	—	bal.	
	COMPOSITION OF SINTERED BODY	24.5	5.5	0.5	0.5	0.05	0.20	1.0	0.20	bal.	
11	LOW R ALLOY	23.0	6.1	0.55	—	0.05	0.20	1.1	0.22(Ti)	bal.	
	HIGH R ALLOY	40.3	—	—	5.1	0.05	0.20	—	—	bal.	
11	COMPOSITION OF SINTERED BODY	24.5	5.5	0.5	0.5	0.05	0.20	1.0	0.20	bal.	

FIG. 11

SAMPLE NO.	T <sub>s</sub> (°C)	d [μm]	ρ [Mg/m <sup>3</sup> ]	B <sub>r</sub> [T]	H <sub>cJ</sub> [kA/m]	(BH) <sub>max</sub> [kJ/m <sup>3</sup> ]	H <sub>k</sub> /H <sub>cJ</sub> [%]	O <sub>2</sub> [ppm]	N <sub>2</sub> [ppm]	C [ppm]
9	1070	4.3	7.53	1.435	1027.8	356.2	60.22	2000	320	690
10	1070	4.2	7.53	1.439	1088.3	400.2	98.16	1800	340	650
11	1070	4.1	7.53	1.432	1080.1	380.2	97.67	2300	240	720

FIG. 12

MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)		
	SAMPLE NO. 9	SAMPLE NO. 10	SAMPLE NO. 11
0	0	0	0
80	6.3	8.9	6.5
160	10.9	20.3	13.6
240	26.4	42.5	29.9
320	48.2	61.0	49.8
400	63.1	75.4	64.9
800	93.6	97.2	95.6
1600	100	100	100
2000	100	100	100

FIG. 13

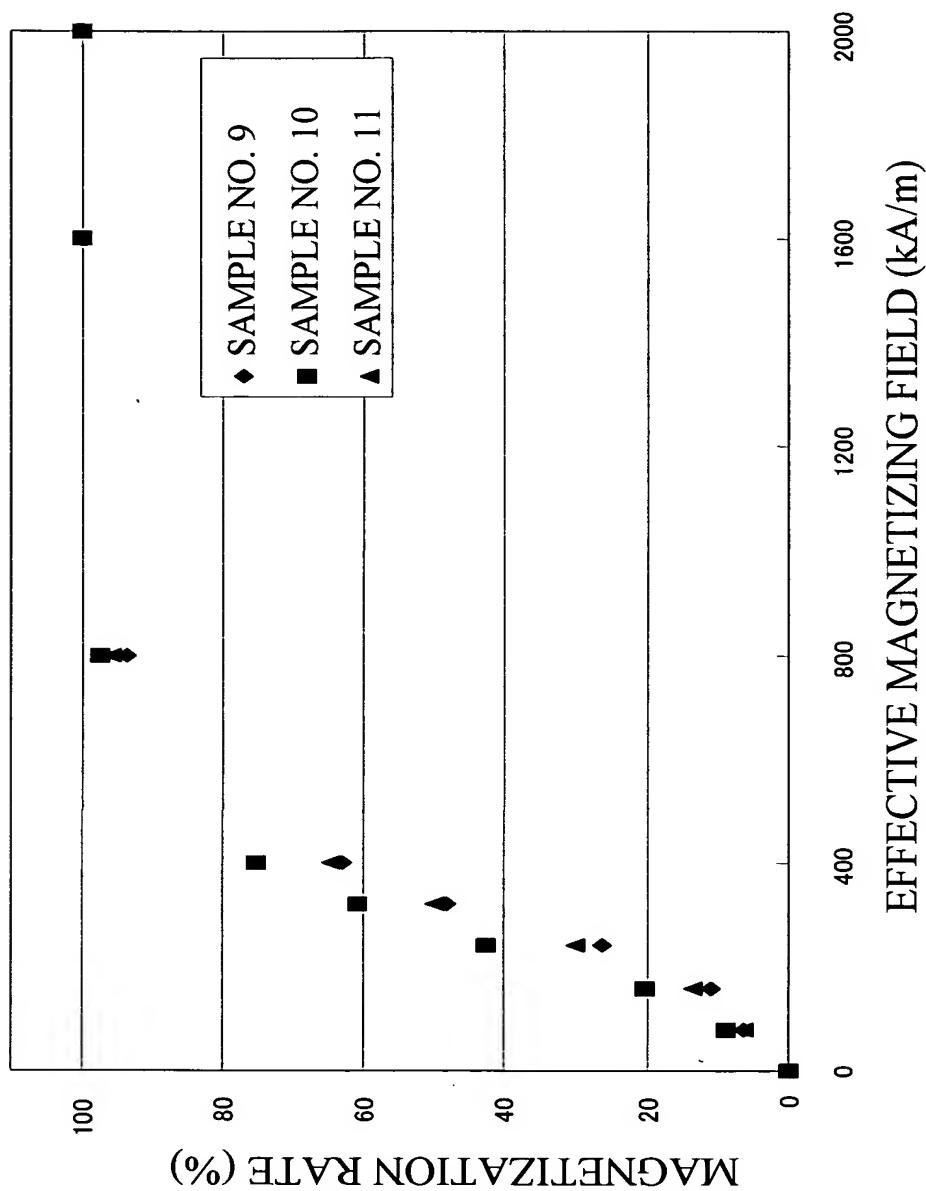


FIG. 14

SAMPLE NO.		Nd	Pr	Dy	Co	Cu	Al	B	Zr	Fe	[wt%]
12	LOW R ALLOY	22.7	6.1	1.1	—	0.05	0.20	1.1	0.15	—	bal.
	HIGH R ALLOY	40.3	—	—	5.1	0.05	0.20	—	—	—	bal.
	COMPOSITION OF SINTERED BODY	24.5	5.5	1.0	0.5	0.05	0.20	1.0	0.14	—	bal.
13	LOW R ALLOY	29.6	6.8	0.13	—	—	0.22	1.1	—	—	bal.
	HIGH R ALLOY	55.4	—	—	5.0	0.07	—	—	—	—	bal.
	COMPOSITION OF SINTERED BODY	26.0	5.5	0.1	0.5	0.07	0.25	1.0	—	—	bal.
14	LOW R ALLOY	21.8	6.0	2.2	—	0.05	0.20	1.12	0.15	—	bal.
	HIGH R ALLOY	40.3	—	—	5.1	0.05	0.20	—	—	—	bal.
	COMPOSITION OF SINTERED BODY	23.2	5.5	2.0	0.5	0.05	0.20	1.00	0.14	—	bal.

FIG. 15

SAMPLE NO.	T <sub>s</sub> (°C)	d [ $\mu$ m]	$\rho$ [Mg/m <sup>3</sup> ]	B <sub>r</sub> [T]	H <sub>c</sub> J [kA/m]	(B/H) <sub>max</sub> [kJ/m <sup>3</sup> ]	H <sub>k</sub> /H <sub>c</sub> J [%]	O <sub>2</sub> [ppm]	N <sub>2</sub> [ppm]	C [ppm]
12	1060	4.3	7.53	1.407	1115.2	382.7	97.80	720	390	800
13	1040	4.3	7.52	1.403	1110.3	381.9	98.30	4800	120	800
14	1060	4.1	7.51	1.388	1335.1	367.3	98.34	830	410	900

FIG. 16

MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)		
	SAMPLE NO. 12	SAMPLE NO. 13	SAMPLE NO. 14
0	0	0	0
80	8.6	5.5	11.2
160	27.8	10.5	31.4
240	54.3	24.1	55.5
320	73.5	41.8	72.3
400	83.5	60.3	80.4
480	87.7	73.4	85.0
560	90.4	82.3	88.4
640	92.7	88.2	91.2
800	96.2	94.9	95.9
960	98.1	98.3	97.9
1200	99.4	100	99.4
1600	100	100	99.6
2000	100	100	100

FIG. 17

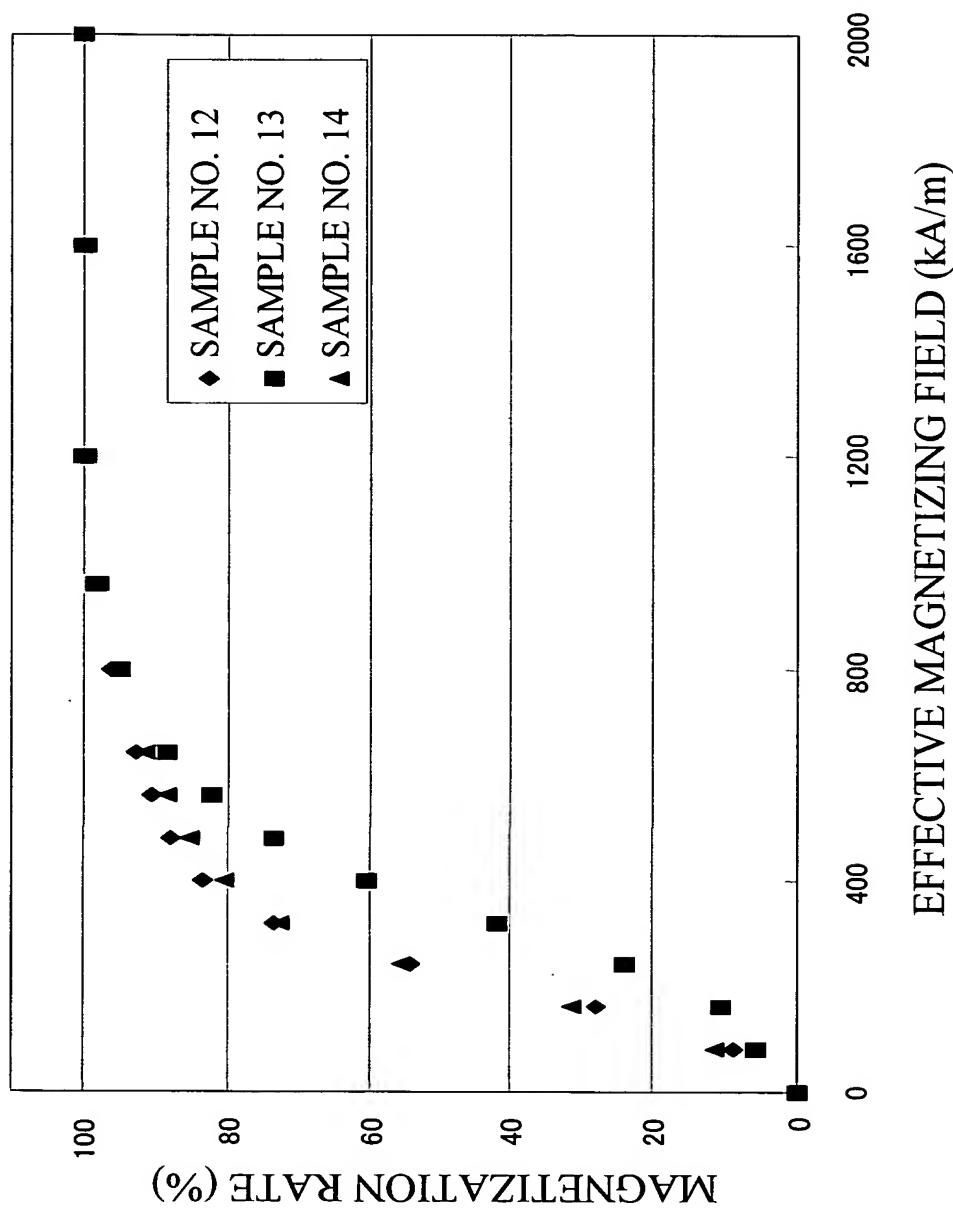
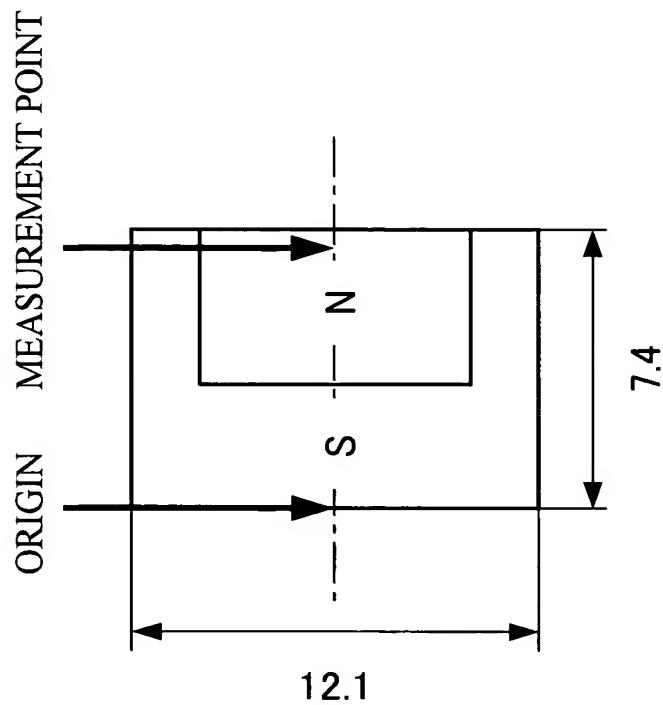


FIG. 18



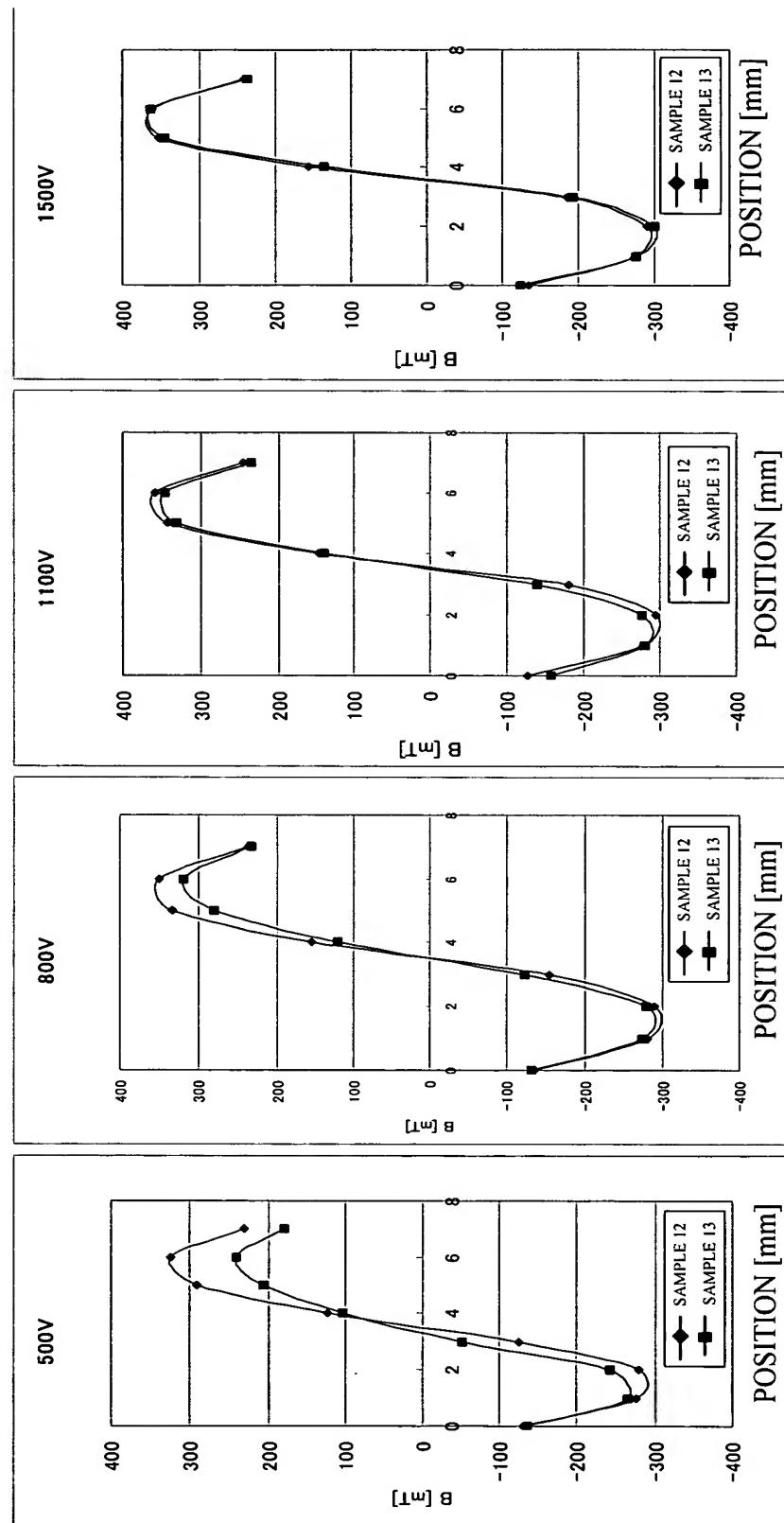


FIG. 19

FIG. 20

SAMPLE NO.	T <sub>s</sub> (°C)	d [ $\mu$ m]	$\rho$ [ $Mg/m^3$ ]	B <sub>r</sub> [T]	H <sub>cJ</sub> [kA/m]	(BH) <sub>max</sub> [kJ/m <sup>3</sup> ]	H <sub>K</sub> /H <sub>cJ</sub> [%]	O <sub>2</sub> [ppm]	N <sub>2</sub> [ppm]	C [ppm]
15	1060	4.2	7.52	1.441	1074.3	401.9	97.53	790	450	880

FIG. 21

MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)		
	Pc=2.0	Pc=1.0	Pc=0.5
0	0	0	0
80	10.9	8.5	6.3
160	30.4	25.9	17.5
240	52.8	47.6	34.9
320	69.2	63.1	50.8
800	95.2	93.3	83.3
1600	100	99.7	99.2
2000	100	100	100

FIG. 22

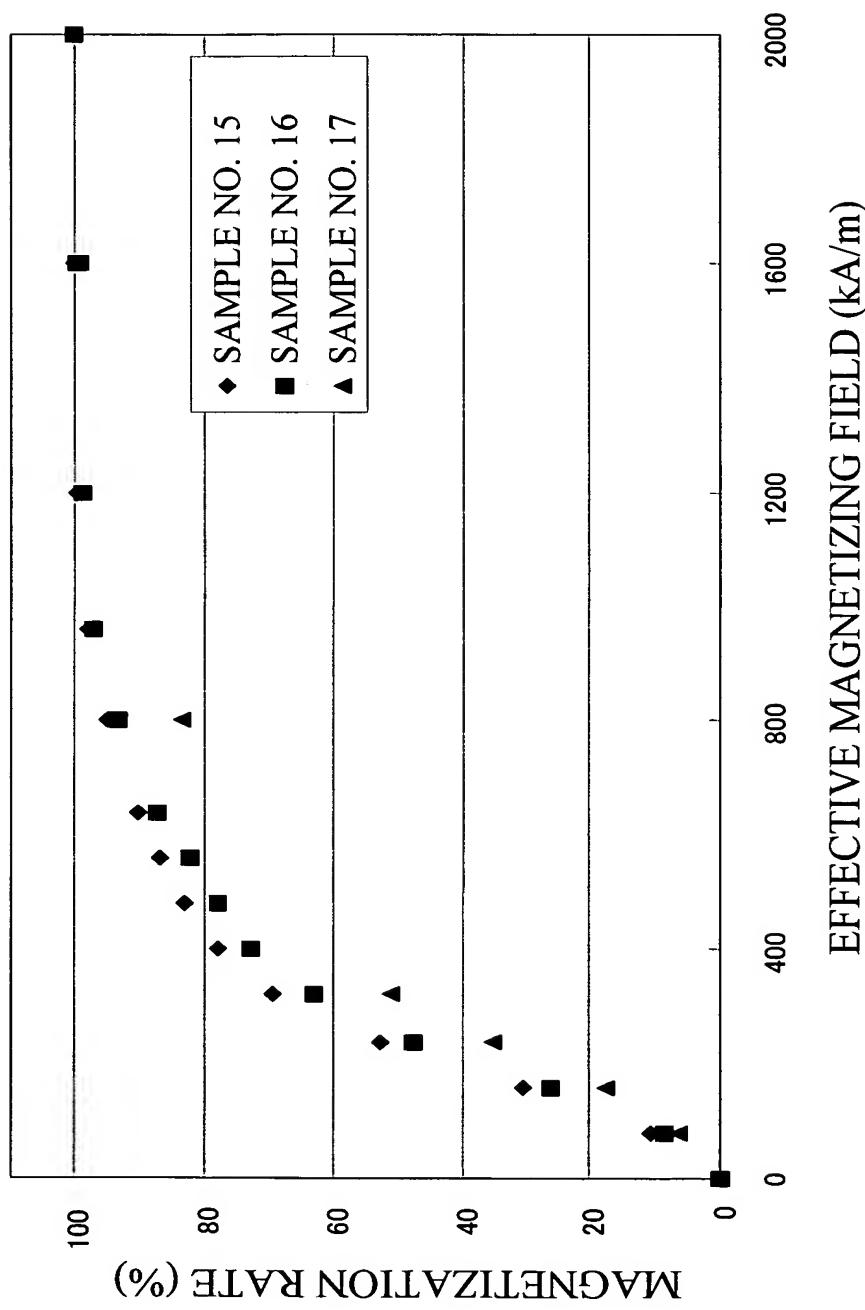


FIG. 23

	Nd	Pr	Dy	Tb	Co	Cu	Al	B	Nb	Fe	[wt%]
COMPOSITION 1	27.73	-	-	3.58	0.59	0.13	0.25	1.01	0.70	bal.	

FIG. 24

SAMPLE NO.	d [ $\mu$ m]	$\rho$ [Mg/m <sup>3</sup> ]	Br [T]	HcJ [kA/m]	(BH)max [kJ/m <sup>3</sup> ]	Hk/HcJ [%]	O <sub>2</sub> [ppm]	N <sub>2</sub> [ppm]	C [ppm]	REMARKS
18	3.3	7.585	1.319	2205	337.8	90.9	960	450	920	
19	3.7	7.594	1.317	2179	340.1	95.4	840	420	880	
20	4.1	7.589	1.316	2151	341.0	96.0	820	400	900	
21	4.4	7.592	1.316	2138	340.2	94.9	770	370	870	COMPOSITION 1
22	4.8	7.586	1.315	2104	340.6	94.5	780	360	870	
23	5.3	7.581	1.315	2066	339.3	94.0	750	350	890	

FIG. 25

MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)			
	SAMPLE NO. 18 (d=3.3 $\mu$ m)	SAMPLE NO. 19 (d=3.7 $\mu$ m)	SAMPLE NO. 20 (d=4.1 $\mu$ m)	SAMPLE NO. 21 (d=4.4 $\mu$ m)
0	0	0	0	0
80	9.9	13.3	13.6	13.2
160	31.2	37.4	39.1	39.0
240	53.2	65.9	68.2	67.4
320	73.4	82.5	83.6	83.2
400	83.3	88.4	90.0	90.3
560	91.2	94.5	95.1	95.2
800	95.6	98.1	98.2	97.8
1200	99.1	100	100.0	100
1600	100	100	100.0	100
2000	100	100	100.0	100

FIG. 26

	Nd	Pr	Dy	Tb	Co	Cu	Al	B	Nb	Fe	[wt%]
COMPOSITION 2	25.53	-	-	4.78	0.59	0.13	0.25	1.01	0.70	bal.	

FIG. 27

SAMPLE NO.	d [ $\mu$ m]	$\rho$ [Mg/m <sup>3</sup> ]	Br [T]	HcJ [kA/m]	(BH) <sub>max</sub> [kJ/m <sup>3</sup> ]	Hk/HcJ [%]	O <sub>2</sub> [ppm]	N <sub>2</sub> [ppm]	C [ppm]	REMARKS
24	4.2	7.598	1.307	2432	332.3	95.8	490	390	390	810
25	4.1	7.596	1.307	2440	332.6	97.0	910	370	370	820
26	4.1	7.593	1.306	2422	333.5	97.4	1350	340	340	800 COMPOSITION 2
27	4.1	7.594	1.306	2399	331.7	96.8	1890	300	300	830
28	4.0	7.585	1.303	2335	331.5	96.6	2580	180	180	820

FIG. 28

MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)		
	SAMPLE NO. 24 (O <sub>2</sub> =490)	SAMPLE NO. 25 (O <sub>2</sub> =910)	SAMPLE NO. 26 (O <sub>2</sub> =1350)
0	0	0	0
80	17.3	16.0	15.4
160	56.2	55.7	52.4
240	79.1	78.3	75.3
320	90.4	89.6	86.2
400	94.5	94.3	93.1
560	97.6	97.2	96.9
800	100	99.1	100
1200	100	100	100
1600	100	100	100
2400	100	100	100

FIG. 29

	[wt%]									
	Nd	Pr	Dy	Tb	Co	Cu	Al	B	M	Fe
COMPOSITION 1	27.73	-	-	3.58	0.59	0.13	0.25	1.0	Nb=0.7	bal.
COMPOSITION 3	27.85	-	-	3.62	0.57	0.14	0.24	1.0	-	bal.
COMPOSITION 4	27.69	-	-	3.55	0.60	0.13	0.25	1.0	Nb=1.4	bal.
COMPOSITION 5	27.83	-	-	3.58	0.57	0.13	0.25	1.0	Zr=0.15	bal.
COMPOSITION 6	27.78	-	-	3.51	0.59	0.14	0.25	1.0	Ta=0.7	bal.
COMPOSITION 7	27.87	-	-	3.55	0.55	0.13	0.24	1.0	Bi=0.07	bal.
COMPOSITION 8	27.89	-	-	3.5	0.59	0.13	0.23	1.0	Ga=0.5	bal.
COMPOSITION 9	27.74	-	-	3.64	0.55	0.14	0.26	1.0	Sn=0.7	bal.
COMPOSITION 10	27.80	-	-	3.48	0.54	0.13	0.24	1.0	Zr=0.1 Nb=0.2	bal.

FIG. 30

SAMPLE NO.	d [μm]	ρ [Mg/m <sup>3</sup> ]	Br [T]	HcJ [kA/m]	(BH)max [kJ/m <sup>3</sup> ]	Hk/HcJ [%]	O <sub>2</sub> [ppm]	N <sub>2</sub> [ppm]	C [ppm]	REMARKS
18	4.1	7.589	1.316	2151	341.0	96.0	820	400	900	COMPOSITION 1
29	4.3	7.577	1.34	2044	352.5	93.6	1360	370	820	COMPOSITION 3
30	4.0	7.583	1.301	2246	329.4	97.6	1140	390	850	COMPOSITION 4
31	3.9	7.585	1.338	2064	355.4	95.1	950	400	860	COMPOSITION 5
32	4.2	7.579	1.314	2167	339.8	96.5	1010	380	880	COMPOSITION 6
33	4.6	7.582	1.336	2134	353.2	95.9	1220	370	840	COMPOSITION 7
34	4.2	7.576	1.324	2287	345.0	96.2	990	410	850	COMPOSITION 8
35	4.1	7.580	1.321	2196	342.6	95.6	1040	390	880	COMPOSITION 9
36	3.9	7.585	1.331	2144	350.1	97.1	1250	420	840	COMPOSITION 10

FIG. 31

MAGNETIZING FIELD (kA/m)	SAMPLE NO. 18 (Nb=0.7)	SAMPLE NO. 29 (Nb=1.4)	MAGNETIZATION RATE (%)					
			SAMPLE NO. 30 (Nb=1.4)	SAMPLE NO. 31 (Nb=1.4)	SAMPLE NO. 32 (Zr=0.15)	SAMPLE NO. 33 (Ta=0.7)	SAMPLE NO. 34 (Bi=0.07)	SAMPLE NO. 35 (Ga=0.5)
0	0	0	0	0	0	0	0	0
80	13.6	9.9	14.5	13.8	12.8	12.4	13.1	13.3
160	39.1	28.4	40.6	40.2	37.4	36.1	38.6	37.9
240	68.2	49.8	68.7	69	64.3	62.2	67.8	68
320	83.6	71.8	84	84.2	80.4	77.8	83.6	84
400	90.0	83.5	90.7	91.0	88.4	87.8	90.3	90.3
560	94.5	91.2	95.5	95.5	94.1	93.9	95.5	95.5
800	98.2	94.7	98.2	99.1	97.7	96.9	98.2	98.2
1600	100.0	98.7	100	100	99.1	99.1	100	100
2000	100.0	100	100	100	100	100	100	100

FIG. 32

	Nd	Pr	Dy	Tb	Co	Cu	Al	B	Nb	Fe	[wt%]
COMPOSITION 11	26.5	3.1	2.0	—	0.7	0.08	0.25	1.0	—	bal.	
COMPOSITION 12	24.2	3.0	4.4	—	0.7	0.08	0.25	1.0	—	bal.	
COMPOSITION 13	22.8	2.9	5.8	—	0.7	0.08	0.25	1.0	—	bal.	
COMPOSITION 14	20.5	2.9	8.1	—	0.7	0.08	0.25	1.0	—	bal.	

FIG. 33

SAMPLE NO.	d [ $\mu$ m]	$\rho$ [Mg/m <sup>3</sup> ]	Br [T]	HcJ [kA/m]	(BH) <sub>max</sub> [kJ/m <sup>3</sup> ]	Hk/HcJ [%]	O <sub>2</sub> [ppm]	N <sub>2</sub> [ppm]	C [ppm]	REMARKS
37	4.1	7.539	1.383	1196	366.2	97.3	1770	110	790	COMPOSITION 11
38	4.1	7.577	1.301	1698	326.5	96.8	1810	110	820	COMPOSITION 12
39	4.0	7.581	1.262	2015	293.8	97.1	1690	120	770	COMPOSITION 13
40	4.1	7.594	1.201	2435	271.4	97.0	1820	100	770	COMPOSITION 14

FIG. 34

MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)		
	SAMPLE NO. 37 (Dy=2.0)	SAMPLE NO. 38 (Dy=4.4)	SAMPLE NO. 39 (Dy=5.8)
0	0	0	0
80	11.0	12.1	13.5
160	28.7	35.4	36.9
240	52.1	62.2	65.4
320	69.5	78.5	83.1
400	83.2	88.2	90.9
560	92.1	94.7	96.7
800	97.4	99.1	99.8
1600	99.1	100	100
2000	100	100	100

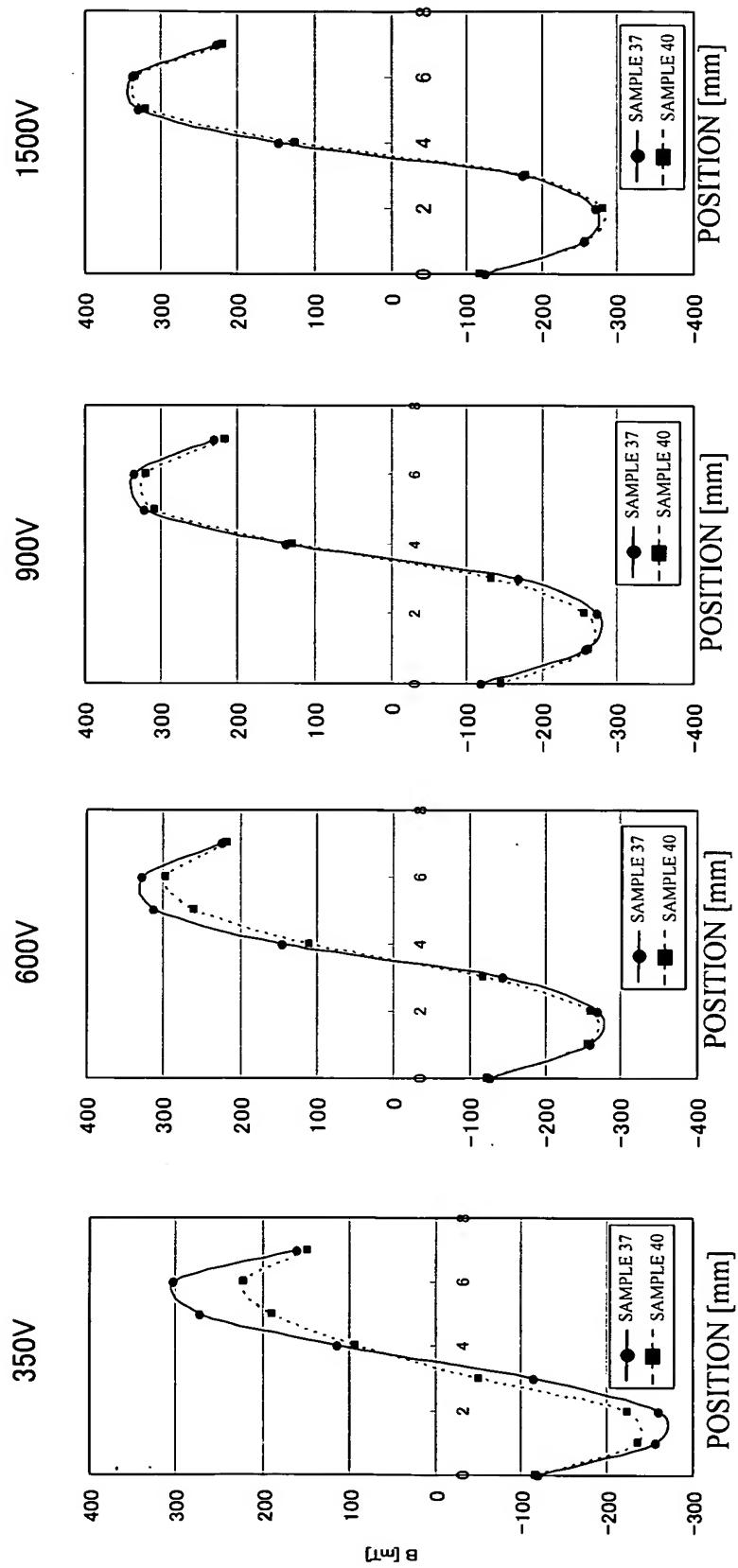


FIG. 35

FIG. 36

	Nd	Pr	Dy	Tb	Co	Cu	Al	B	Nb	Fe	[wt%]
COMPOSITION 15	27.3	3.0	—	0.7	0.7	0.08	0.25	1.0	—	—	bal.
COMPOSITION 16	26.7	3.0	—	1.2	0.7	0.08	0.25	1.0	—	—	bal.
COMPOSITION 17	24.0	2.9	—	3.6	0.7	0.08	0.25	1.0	—	—	bal.
COMPOSITION 18	22.6	3.0	—	5.0	0.7	0.08	0.25	1.0	—	—	bal.

FIG. 37

SAMPLE NO.	d [ $\mu$ m]	$\rho$ [ $\text{Mg/m}^3$ ]	Br [T]	Hcj [kA/m]	(BH) <sub>max</sub> [kJ/m <sup>3</sup> ]	Hk/Hcj [%]	O <sub>2</sub> [ppm]	N <sub>2</sub> [ppm]	C [ppm]	REMARKS
41	4.1	7.542	1.396	1253	379.2	96.9	1710	130	760	COMPOSITION 15
42	4.2	7.558	1.380	1398	370.4	97.2	1920	120	780	COMPOSITION 16
43	4.0	7.579	1.321	2090	339.5	96.6	1740	130	760	COMPOSITION 17
44	4.3	7.588	1.282	2488	320.1	96.7	1800	110	770	COMPOSITION 18

FIG. 38

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R-T-B System Rare Earth Permanent...  
EV 325 215 155 US  
33 Drawing Sheets; Sheet 32 of 33

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MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)		
	SAMPLE NO. 41 (T <sub>b</sub> =0.7)	SAMPLE NO. 42 (T <sub>b</sub> =1.2)	SAMPLE NO. 43 (T <sub>b</sub> =3.6)
0	0	0	0
80	10.2	12.2	13.2
160	26.7	32.5	36.1
240	51.7	60.9	63.4
320	70.2	76.2	78.9
400	82.1	85.4	87.0
560	90.0	92.6	94
800	95.2	97.1	98.3
1600	99.1	100	100
2000	100	100	100

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FIG. 39

MAGNETIZING FIELD (kA/m)	MAGNETIZATION RATE (%)		
	SAMPLE NO. 19 (P <sub>c</sub> =2.0)	SAMPLE NO. 45 (P <sub>c</sub> =1.0)	SAMPLE NO. 46 (P <sub>c</sub> =0.5)
0	0	0	0
80	13.3	10.4	7.3
160	37.4	31.9	21.8
240	65.9	58.7	44.2
320	82.5	76.3	60.9
400	88.4	84.2	70.8
560	94.5	91.6	81.2
800	98.1	96.3	89.5
1600	100	100	99.1
2000	100	100	100